Introduction

Mining in the Black Hills of South Dakota and Wyoming dates back to approximately 1876 following the discovery of gold near Custer, S.D., during the 1874 expedition of General Custer through the Black Hills. Although gold and silver have historically (and presently) been the most important commodities produced from the mines in the Black Hills, other mineral production has been quite diverse for an area of such relatively small extent. Industrial non-metallic materials have been mined from Paleozoic and Mesozoic sediments and Precambrian pegmatites, producing limestone, gypsum, iron ore (Portland cement and aggregate), bentonite (steel), feldspar (porcelains, etc.), spodumene (Li), mica (Cs, Li, and vermiculite), and quartz. By-products from pegmatite mines have also included such commodities as beryl, columbite-tantalite, and tin. Production of metallic commodities from mines in rocks ranging in age from Precambrian to Tertiary have included Au, Ag, Pb, Zn, and W.

Current and historic production of Au and Ag has largely been from mines in the northern Black Hills centered around the towns of Lead and Deadwood. Although the Homestake Mine has been the single largest producer of gold and silver (about 36,000,000 oz Au and 7,000,000 oz Ag) from the Precambrian Homestake formation, significant production, summarized in Table 1, has also come from Paleozoic sedimentary rocks and Tertiary igneous rocks.

This paper is an attempt to outline 1.) the characteristics of the Precambrian metamorphic rocks, Paleozoic sediments, and Tertiary igneous rocks; 2.) the controls of Au and Ag mineralization; and 3.) the distribution of Au and Ag mineralization as it is found in the Lead-Deadwood area.

Table 1. - Gold production of the Black Hills, 1875-1971

Mine or locality	Location	Principal source of ore[1]	Gold produced (in troy ounces)[2]
Principal mines:			
Homestake	At Lead, Lawrence County	pCif	31,446,997
Golden Reward group of mines	2 mi. (3 km) SW. of Lead	€dd	[3]950,000
Bald Mountain group of mines	3 mi. (5 km) W. of Lead	€dd	[4]836,000
Mogul	3 mi. SW. of Lead	€dd	[5]350,000
Placers of Deadwood region	Near Deadwood	QTp	[6]200,000
Maitland (Penobscot)	3 mi. NNW. of Lead	€dd	147,000
Wasp No. 2	2 mi. S. of Lead	€dd	[7]120,000
Keystone and Holy Terror	At Keystone, Pennington County	pCq	86,000
Gilt Edge	5 mi. (8 km) ESE. of Lead	Ti	56,000
Spearfish Gold	7 mi. (11 km) W. of Lead	Mp	[8]45,464
Clover Leaf (or Uncle Sam)	At Roubaix, 7 mi. SE. of Lead	pCq	43,385
Lundberg, Dorr, and Wilson	2 mi. WSW. of Lead	€dd	43,617
Hoodoo-Union Hill	5 mi. ESE. of Lead	Ti	[9]30,000
Reliance	5 mi. W. of Lead	€dd	27,003
Rockerville placers	Just E. of Rockerville, Pennington County	QTp and €dc	[10]20,000
Ragged Top	6 mi. W. of Lead	Mp	15,800
Deadwood Standard	7 mi. W. of Lead	Mp	11,953
J.R.	3 mi. N. 60° E. of Hill City, Pennington County	pCq	11,500
Hidden Fortune	Just N. of Lead	€dd	10,997
Other deposits:[11]			
Lawrence County (especially Alder Creek, Cleopatra, Bismarck, Golden Crest, Monarch, and Kicking Horse).[12]		€dd	50,000
Pennington County (especially Empire, Bullion, Standby, and Sunnyside).[13]		pCif and pCq	30,000
Custer County		pCq	4,000
Total production from identified sources			34,536,246
Production from unidentified sources			158,306
Total recorded production			34,694,552

[1] pCif, Precambrian iron-formation; pCq, quartz veins in Precambrian metamorphic rocks; €dc, conglomerate at the base of the Deadwood Formation; €dd, replacement bodies and veins in dolomite and other rocks of the Deadwood Formation; Mp, Pahasapa Limestone; Ti, Tertiary igneous rocks; QTp, Quaternary and Tertiary placer deposits.

[2] Chief source of information is Allsman (1940), other sources (except for the Deadwood and Rockerville placers) are U.S. Bureau of Mines Minerals Yearbooks, Reports of the South Dakota State Mine Inspector, Slaughter (1968, p. 1438), U.S. Bureau of Mines (1954, 1955), Irving (1904, p. 117-118), and Shapiro and Gries (1970, p. 190-194). Many figures are in part estimates, several of which are based on published statements of the probable dollar value of production during years prior to 1900 for which no exact records exist; other estimates, for years after 1937, were obtained by subtracting the published or probable production figures of other mines from the total South Dakota production in that year.

[3] Allsman (1940, p. 38-39) recorded production from the Golden Reward for 1991-11 as only 371,382 ounces of gold and 734,223 ounces of silver, but he stated that incomplete records for earlier years suggest a total production of about $21 million in bullion. This large total implies that the Golden Reward gold production cannot have been less than the 950,000 ounces used here, which makes the Golden Reward group of properties the second largest source of gold in the Black Hills. The Bald Mountain group of mines has traditionally been regarded as holding the second ranking position, and tradition may well be correct, for its production of 836,000 ounces is almost completely documented.

[4] The production of the Bald Mountain group of mines is the total of (1) 487,877 ounces for 1901-37 published by Allsman (1940, p. 28); (2) about 342,000 ounces for 1938-59 either known or readily deduced as coming from the Bald Mountain operation from U.S. Bureau of Mines Minerals Yearbook figures and from Slaughter (1968, table 1); and (3) apparently small production prior to 1901, of which only an estimated 5,700 ounces from the Clinton and Dividend properties seems to be recorded (Irving, 1904, p. 118). This brings the total, in round figures, to 836,000 ounces. Unfortunately, Miller (1962, p. 114-115), whose data should be authoritative, gives figures that (after subtracting the Mogul production, which is here treated separately) total only 757,858 ounces. Miller and Allsman are substantially in agreement for the period 1901-37. The main discrepancy lies in the 1938-59 figures, for which Miller seems to use 271,561 ounces instead of the 342,000 ounces used here.

[5] Allsman (1940, p. 38) recorded production of 212,679 ounces for 1902-17. He also said that scattered records indicate about $3 million in bullion produced in earlier years. This amount, after allowance is made for silver, suggests 138,000 ounces of gold, which brings the total gold production, in round figures, to 350,000 ounces.

[6] Bergendahl (1964, p. 41). Source of information is unstated, but oral communications with him and A.H. Koschmann during the late 1950's, when they were compiling gold production data from many sources, suggest that this figure is based on U.S. Mint records of gold receipts from this region during years when the only large production was from placers at Deadwood.

[7] Allsman (1940, p. 40) recorded 100,819 ounces for 1901-20 and said that $500,000 or less was produced in earlier years, which indicates a total of about 120,000 ounces.

[8] Omits Allsman's figure of 3,150 ounces for 1899, which according to Shapiro and Gries (1970, p. 167) came mostly or entirely from elsewhere.

[9] The Hoodoo-Union Hill deposits (Allsman, 1940, p. 63) had a production of at least $150,000 in gold, and the company owning the property produced $800,000 from this and other sources. The 30,000-ounce estimate used here is nearer the larger figure than the smaller one.

[10] Parker (1966, p. 87) seems to be the only author who has ventured an estimate of the Rockerville production, which, without citing a source, he places at $400,000 in 1877 and 1878 and at more than $500,000 within a few years thereafter. The amount of disturbed ground in Rockerville Gulch and along the base of the Deadwood Formation suggests that production was indeed substantial, but it was probably not as large as Parker states. The estimate of 20,000 ounces used here is merely a guess but probably is as accurate as any that can be made now.

[11] None of the hundreds of small placer deposits mined after the gold rush years are included.

[12] Mines specifically named are those that have a recorded or estimated production of between 3,000 and 10,000 ounces.

Geology of the Precambrian Metamorphic Rocks

The "Lead-Deadwood Window" is an exposure of Precambrian metamorphic rocks that consist of over 15,000 feet of detrital and chemical sediments and lesser amphibolites or meta-basalts (Fig. 1). The metasediments were probably deposited originally in a subsiding basin or eugeosynclinal environment and range between 2.1 b.y. to 1.7 b.y. old. Detailed descriptions of the stratigraphy in this area have been published by Bayley (1970), Noble and Harder (1948), and Slaughter (1968), to which the reader is referred for additional information.

The lowest unit in the Precambrian stratigraphic sequence, is the Poorman formation. It is at least 2000 feet thick, but the base is not exposed, so the exact thickness is not known. The Poorman is largely a laminated, dark grey phyllite. Mineralogically, it is comprised of quartz, sericite, graphite, iron oxides, and ankerite in order of decreasing abundance.

The Homestake formation lies conformably on the Poorman formation and ranges from 200 to 300 feet thick. Outcrops of the Homestake are generally reddish-brown, but in the Homestake Mine, they are more commonly green-brown to green. It is a fine-grained, bedded Mg-siderite (sideropleisite)-quartz or a cummingtonite-quartz schist depending upon metamorphic grade. It is comprised of cummingtonite (or Mg-siderite), quartz, biotite, chlorite, and graphite. The quartz occurs as pods or lenses of recrystallized chert. The original sediment probably consisted of alternating layers of Mg-siderite and chert; i.e., a carbonate facies iron formation. This metasedimentary unit is repeated as thin discontinuous beds or lenses in the upper Poorman formation, lower and upper Ellisor formation, and in the Flag Rock formation.

The Ellison formation conformably overlies the Homestake formation and ranges from 3000 to 5000 feet thick. It has been divided into a lower

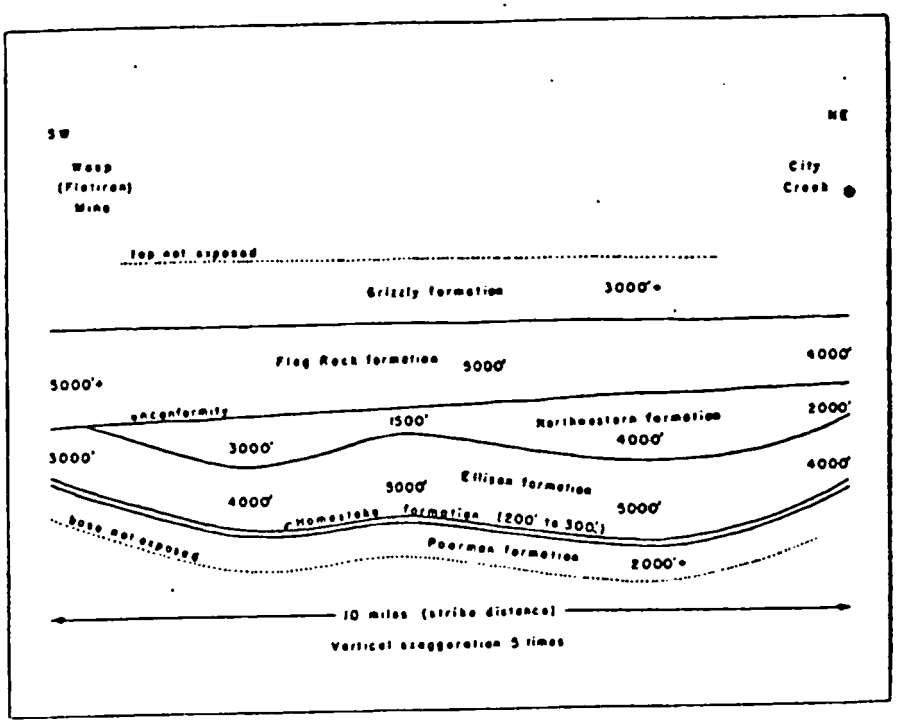

Figure 1. - Stratigraphic column of the Precambrian rocks in the Lead-Deadwood area.

member consisting of quartzites and phyllites (approximately 1200 feet thick), a middle phyllite member (approximately 1500 feet thick), and an upper quartzite and phyllite member (between 1200 and 2000 feet thick). Laminations and banding in the phyllites are not as common as found in the Poorman formation and the quartzites are generally massive. Phyllites consist of mostly quartz and muscovite with minor biotite and ankerite. Quartzites consist largely of quartz, graphite, iron oxides, sericitic muscovite and minor ankerite.

Conformably overlying the Ellison formation is the Northwestern formation which is as much as 4000 feet thick. The formation consists largely of phyllite and schist which shows no bedding or layering. Mineralogically, it is comprised of quartz, sericitic muscovite, biotite, and minor tourmaline and sphene. The formation thins to approximately 2000 feet north of Deadwood, and disappears entirely to the south of Lead.

The Flag Rock formation rests unconformably on the Northwestern formation or the Ellison formation where the Northwestern is absent. The Flag Rock is a heterogeneous sequence of largely light gray sericitic phyllite or schist, streaky quartzite and/or metachert, cherty ferruginous schist and amphibolites (metabasalts); the latter having been included in the formation by Bayley (1970). The formation is as much as 5000 feet thick. Thy phyllite and schist is comprised of quartz, muscovite, graphite, iron oxides and minor tourmaline. Streaky quartzites and metacherts are comprised of largely quartz with 1 mm to several cm dark gray bands of quartz, graphite, iron oxide and minor muscovite and tourmaline. Cherty ferruginous schist is comprised largely of quartz, iron oxide and muscovite. In outcrop this unit is reddish brown and much of the iron oxide is hematite, but in the subsurface the iron oxide is a mixture of hematite and magnetite. The amphibolites (metabasalts) are dark green-gray to black, fine-grained rocks

that are commonly comprised of flattened and elongated ellipsoids (pillows). Mineralogically they are comprised of hornblende and plagioclase.

The Grizzly formation is conformable with the Flag Rock formation and is at least 3000 feet thick; the top of the formation is not exposed. It is comprised of graywackes and quartz-mica schists in the Roubaix area, but these grade into largely quartz-mica schist and phyllite or slate near Lead. These rocks are largely comprised of quartz, muscovite and minor biotite, garnet, iron oxides, and tourmaline.

The Precambrian metasediments in the "Lead-Deadwood Window" are strongly deformed by at least two periods of folding (Noble et. al., 1949) and form an anticlinorium that plunges 25° to 30° to the southeast. This anticlinorium is a series of early isoclinal folds with a steeply dipping, north-northwest trending axial plane foliation. The early folds are cross-folded by tight, northwest trending folds which produced zones of dilation. Cross-folded folds are apparent in plan and cross-section and crenulated foliation and lineations are commonly observed in field exposures and hand specimens (Fig. 2). Chinn (1969) determined three periods of deformation in a detailed structural study of the Homestake Mine. In addition, numerous faults and Tertiary felsic dikes crosscut the metasediments.

The garnet isograd bisects the "Lead Deadwood Window" trending north-northwest with biotite grade metamorphism to the southwest and increasing to staurolite grade in the extreme northeastern corner of the window. Studies in Homestake Mine indicate that the isograds dip gently west so that the garnet grade rocks underly those in the biotite zone (Noble and Harder, 1948).

Figure 2. - Structure of the Precambrian Rocks. The Homestake formation is shaded. Poorman formation, pmf; Ellison formation, ef; Northwestern formation, nwf; Flag Rock formation, frf; Grizzly formation, gf. Large Tertiary intrusives are solid black. Large amphibolite bodies are dotted. Faults are shown by dashed lines. Omitted are Cambrian strata, small Tertiary intrusives, small amphibolites, and Tertiary gravel deposits.

Geology of the Paleozoic Rocks

The Paleozoic sedimentary rocks rest unconformably on the Precambrian metasediments. They are comprised largely of shallow marine beach and tidal flat sediments and shelf sediments deposited in the Paleozoic seaway. Figure 3 is a generalized stratigraphic column of the Paleozoic rocks in the Black Hills.

The Upper Cambrian, Deadwood formation is the lower most sedimentary unit. The formation has been subdivided into lower, middle, and upper members by Kulik (1965). The lower member is generally comprised of 0 to 40 feet of basal conglomerate overlain by 10 to 125 feet of quartz arenite or quartzite followed by up to 50 feet of interbedded shales and limestones. This member especially is characterized by rapid facies changes that reflect the paleotopography of the Precambrian surface onto which the sediments were deposited. The basal conglomerate is generally absent and the quartzite the thinnest on paleohighs, such as those formed along the more resistant Ellison formation quartzites adjacent to the less resistant phyllites. Conversely, relatively thick wedges of conglomerate and quartzite were deposited adjacent to these highs and in erosional channels. The middle member of the Deadwood formation is comprised of approximately 100 to 160 feet of interbedded shales, limestones, and intraformational limestone pebble conglomerates. The upper member ranges from 125 to 160 feet thick and consists of massive red (scolithus) sandstone and flaggy sandstones and limestones.

Overlying the Deadwood formation are the Ordovician Winnipeg and Whitewood formations. The Winnipeg is disconformable with the Deadwood, but the Whitewood and Winnipeg are conformable. They range from 85 to 165 feet thick and are comprised largely of shales, siltstones (locally calcareous) and dolomites.

The Devonian-Mississippean Englewood formation disconformably overlies the

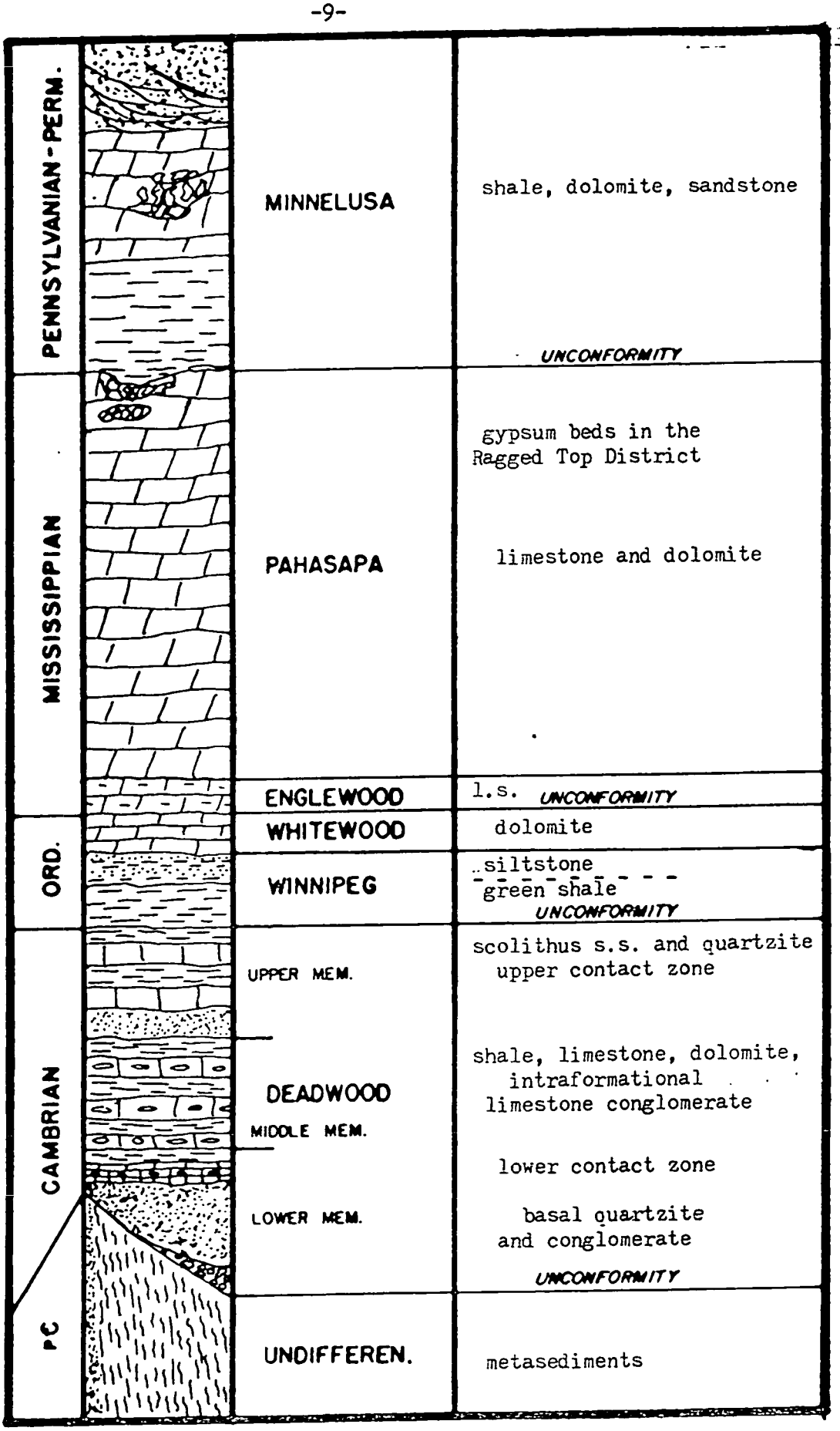

Figure 3. - Stratigraphic column of the Paleozoic rocks in the Lead-Deadwood area.

Whitewood formation. This unit ranges from 35 to 50 feet thick and consists of pink to lavender calcareous siltstone and slabby argillaceous carbonates. The Englewood is conformable with and grades into the overlying Pahasapa formation.

The Pahasapa (Madison) formation is a Mississippean carbonate unit that ranges from 500 to 600 feet thick. It is comprised of crystalline carbonate, argillaceous carbonates that are locally petroliferous, and minor intraformational conglomerates or breccias(?). According to Shapiro and Gries (1970), a pre-Pennsylvania karst topography was developed on the Mississippean surface.

The upper Pennsylvanian-Permian Minnelusa formation unconformably overlies the Pahasapa formation. It ranges from 400 to 500 feet thick and has been subdivided into a lower red shale section, a middle carbonate-gypsum section, and an upper sandstone section. Post depositional dissolution of gypsum and limestone in the middle section has resulted in slump and breccia-like features similar to those that might be developed in karst areas.

Geology of the Tertiary Igneous Rocks

The Tertiary igneous rocks occur in a narrow belt in the northern Black Hills of South Dakota and Wyoming that trends N70° to 75°W. They extend east from Bear Butte to Devil's Tower-Missouri Buttes to the west. According to Lisenbee (1980) they occur along this trend in 13 principal igneous centers and numerous smaller centers (Fig. 4). The intrusives occur as shallow level porphyries emplaced as sills, laccoliths, dikes, and small stocks. In the Lead-Deadwood area, they consist largely of alkaline phonolites, latites, trachytes, and rhyolites and generally range in age from 50 m.y. to 60 m.y. West of the Lead Deadwood area, the intrusives become silica undersaturated phonolites, nepheline and leucite bearing trachytes, and carbonatites that

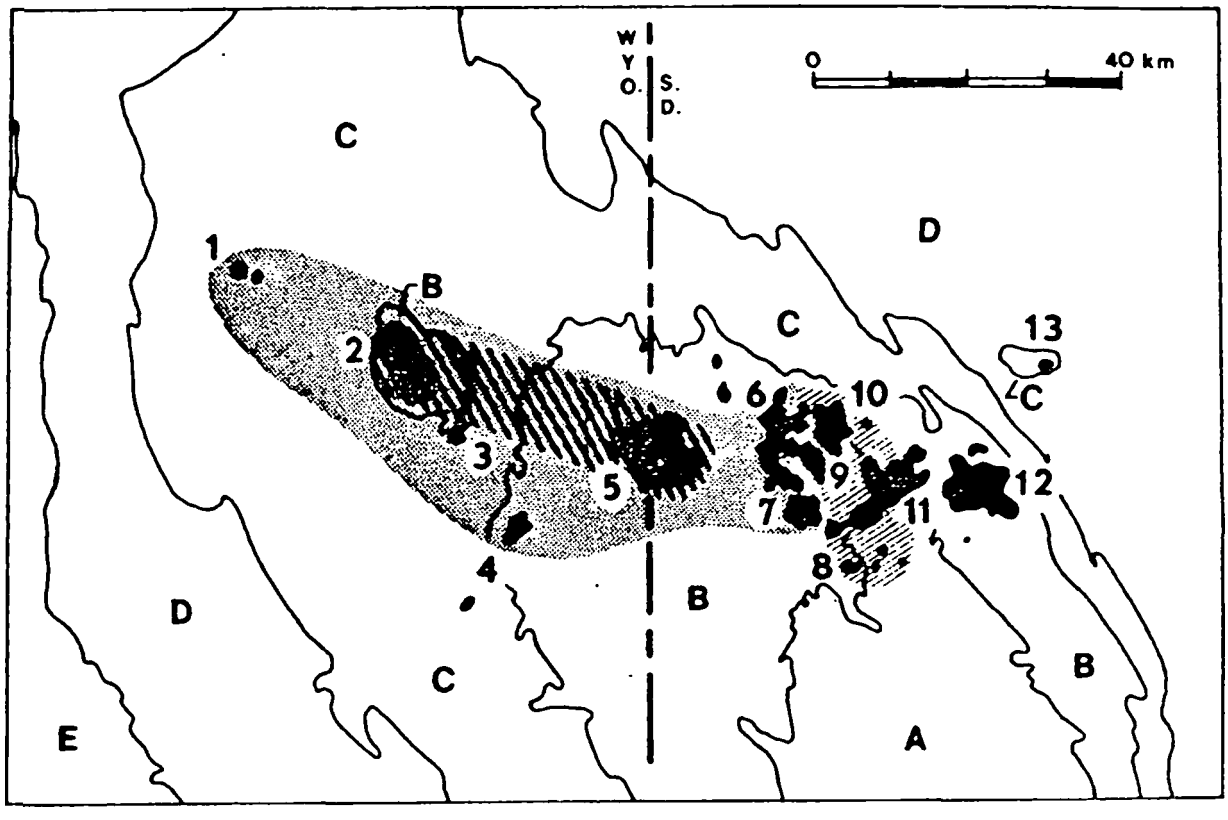

Figure 4. - Tertiary igneous centers and related rock types of the northern Black Hills uplift. Igneous rocks are in black. Stippled pattern indicates centers containing phonolite, heavy diagonal pattern those with carbonatitic affinities and light diagonal pattern those with rhyolite. The centers are: 1) Devil's Tower-Missouri Buttes; 2) Bear Lodge; 3) Sundance Mtn.-Sugarloaf; 4) Black Buttes; 5) Mineral Hill-Tinton; 6) Spearfish-Carbonate; 7) Terry; 8) Strawberry Hill-Tinton; 9) Cutting; 10) Mt. Theodore Roosevelt; 11) Gilt Edge-Galena; 12) Vanocker; 13) Bear Butte. Rock units are: A) Precambrian metamorphic basement; B) Paleozoic sedimentary rocks; C) Upper Permian to pre-Newcastle Sandstone lower Cretaceous sedimentary rocks; D) Cretaceous Newcastle Sandstone to top of Cretaceous sedimentary rocks; E) Tertiary sedimentary rocks.

generally range in age from 40 m.y. to 50 m.y.

The Black Hills form a domal feature that is cored by Precambrian metamorphic rocks which are flanked by Paleozoic and Mesozoic sedimentary rocks that gently dip away from the core. The dome has been subdivided into two structural domains by Noble et. al. (1949) along a north trending lineament through Newcastle, Wyoming. The domains consist of a north-northeast trending domain east of the lineament and a northwesterly trending domain on the west. Figure 5 crudely shows these domains as they are reflected in the structural data. Lisenbee (1980) postulates that uplift started as early as late Cretaceous and continued until middle Tertiary time and that igneous activity is coeval with doming.

Gold and Silver Deposits

Precambrian

The most significant gold mineralization in rocks of Precambrian age, occurs in the Homestake formation of the Lead-Deadwood Window and in Homestake-like amphibolites (cummingtonite-grunerite schists). Minor Au mineralization also occurs in quartz veins and metaconglomerates. Of particular significance is that the majority of Precambrian gold mines occur in rocks that have been metamorphosed to at least garnet grade.

At the Homestake Mine in Lead, S.D., gold ore is virtually confined to the Homestake formation. The formation is extremely variable in thickness being thinned or even pinched out on fold limbs and thickened at fold noses. Therefore, much of the production comes from zones of dilation generally located at fold noses. Gold occurs as native gold that is comprised of approximately 82% Au, 17% Ag and 1% other metals and occurs with auriferous arsenopyrite, pyrrhotite, and graphite. Currently, the ore averages about .17 opt Au. Models that are currently being used for the Homestake deposit

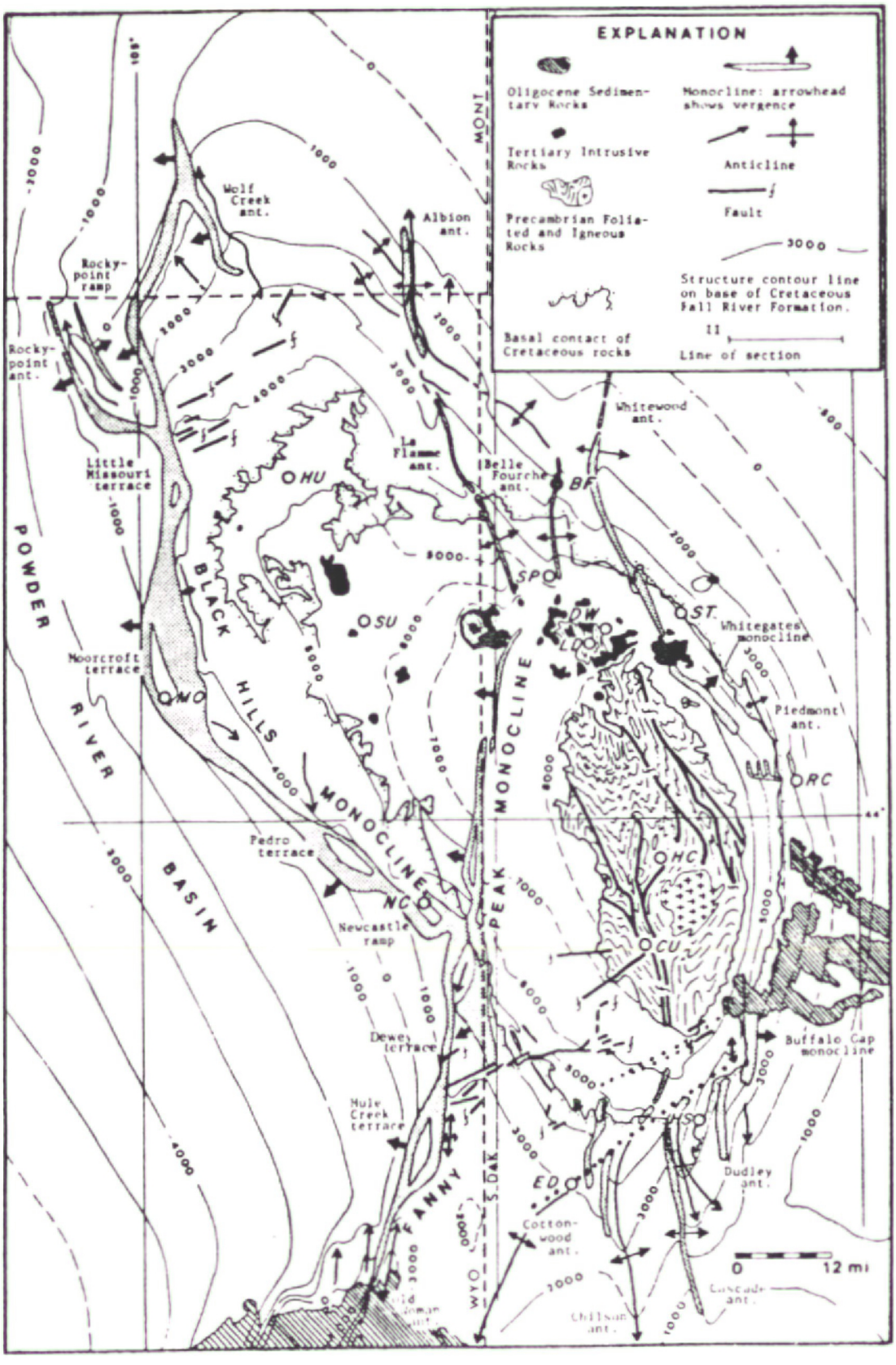

Figure 5. - Tectonic map of the Black Hills region

suggest that it is syngenetic, deposited with an exhalative carbonate iron formation; perhaps associated with distal volcanic activity or exhalative hot spring activity (Rye and Rye, 1974; Hallinger, 1980±). Past workers have postulated that gold was remobilized and concentrated in zones of dilation at fold noses. Hallinger (1980±) has suggested on the basis of geochemical modeling that little if any remobilization took place, but if this is true it is difficult to explain why gold mineralization only seems to occur in rocks that have been metamorphosed to garnet grade.

Other areas of gold production from Homestake-like iron formations include the Rochford area (Standy Mine, Cochran Group), the Keystone area (Bullion Mine), and the Tinton area. These areas have recently gone through a flurry of exploration by HMC, Getty, and Freeport with at least marginal success by HMC in the Keystone area.

Paleozoic Rocks

Paleozoic rocks in the Lead-Deadwood area have historically been the second largest source for production of Au and Ag ores (Table 1). These deposits are generally considered to be Tertiary age, being intimately related to Tertiary igneous activity and therefore, restricted to the northern Black Hills. In general, they occur as replacement deposits in carbonate units along vertical fractures that intersected carbonate or carbonate bearing sediments. Au:Ag ratios tend to be in the range of 1:2 to 1:3, and silicification is a common, if not a ubiquitous feature of these deposits. The majority of production has come from ore bodies in the Cambrian Deadwood and the Mississippean Pahasapa formations.

Production from the Deadwood formation has largely come from sandy dolomites just above the lower quartzite and from carbonates just below the quartz sandstone in the upper member. These mineralized horizons are referred to locally as the "lower and upper contact zones" and generally

range from about 1 to 10 feet thick. The carbonates are largely replaced by silica, pyrite, argentiferous galena, gold tellurides, and native gold and silver. Ore bodies are developed along vertical fractures that are documented to have strike lengths up to 2700 feet with mineralization occurring at several carbonate horizons along fracture intersections with carbonates. Closely spaced fractures associated with mineralization, such as at the Bald Mountain Mines, make near surface deposits amenable to open pit mining methods. The ores are described by Smith (1897) to have occurred as oxidized ("red ore") or as sulphide ("blue ore"). The gold and silver were generally easy to extract from the oxidized ores, while sulphide ores (Au tellurides) required roasting. In addition, some production has come from replacement ore bodies in the carbonates of the middle member which hosts the Au and Ag ore at the currently producing Annie Creek Mine. Finally, ore bodies in the basal conglomerates are paleoplacers deposited along paleohighs adjacent to the Precambrian Ellison and Homestake formations. Irving (1904) stated that the ores commonly occurred as "pay streaks" where gold was probably concentrated by channel currents.

As in the Deadwood formation, ore bodies in the Pahasapa formation occur along vertical fractures in silicified (and dolomitized) carbonates. Although production has come from various levels within the formation, much of the production seems to have come from the upper 150 feet and rarely contains any significant sulphide. Recent work by HMC in the Ragged Top Mining District indicates that mineralization is hosted in a silicified and/or dolomitized "breccia horizon" that is within 100 feet of the surface, ranging from 5 to 50 feet thick. Though the origin of these breccias is still open to debate, they probably formed due to the dissolution of gypsum beds near the top of the formation. Mineralization of the "breccias" was later controlled during the Tertiary by fracturing.

Production of Au and Ag from the Winnipeg, Whitewood and Englewood formations has been minor and there is no recorded production from the Minnelusa formation. These formations should be good hosts for mineralization that could be explored for potential deposits.

Tertiary Rocks

Au and Ag production from Tertiary igneous rocks has historically come mostly from the Gilt Edge group of mines near Galena and the Cutting Mine north of Lead. At both locations, brecciated porphyries host mineralization. Recent exploration by St. Joe in the Richmond Hill area indicates that other porphyry centers may host Au and Ag mineralization.

Mineralization Controls

Factors that seem to control Tertiary Au and Ag mineralization are enumerated below. Although the list is not considered to be complete, it provides some factors to be considered in an exploration program.

1.) Fracturing, fracture zones and brecciation associated with Laramide doming of the Black Hills and Tertiary Intrusive activity (ground preparation) seems to be a prerequisite to mineralization (fracturing is not radial around the "Lead-Deadwood Window"). In areas such as Bald Mountain northwest of Lead, fracturing and mineralization are closely spaced and production of relatively large tonnages occurred. In the Galena Mining District (Ag and Pb) mines were often developed along a single vertical fracture or fracture zone that may have produced high grade ores, but the tonnages produced were generally small. The ability to predict where other highly fractured areas might occur could assist in the attempt in locating other deposits similar to Bald Mountain.

2.) Ore grade mineralization hosted in Tertiary igneous rocks occurs in breccias that are probably related to shearing associated with multiple

igneous intrusions. At Gilt Edge, the shears are best developed along a N35°E to N45°E trend.

Flat lying "breccias" that host mineralization in the Pahasapa formation (Ragged Top District) are best developed within the upper 150 feet of the formation. According to Jennings (1985, personal comm.) a karst topography did develop at the top of the formation, but karst features rarely, if ever, host mineralization because of recementing prior to mineralization. The current model being used by HMC for the deposits at Ragged Top proposes that the "breccias" formed due to the dissolution of gypsum rich beds near the top of the formation and mineralization occurred within these beds along fractures that intersected them. The ore is commonly silicified and/or dolomitized and contains no primary sulphides.

Ground preparation other than fracturing is not documented (if it exists) for ores located in the Deadwood formation. The preponderance of the ores in at least the "lower contact zone" seems to be directly related to the thickness of the carbonates above the lower quartzite, fracture intensity and extent, and the proximity of igneous activity. The thickness of the carbonates above the lower quartzite is probably related to fluctuations in sea level during deposition. Local differences in sea level would have been caused due to the influence of paleotopography on the Precambrian surface. Because carbonates tend to be deposited in relatively shallow water, it seems likely that carbonates should be thickest over paleohighs (e.g., those highs developed over the pC Ellison formation quartzites adjacent to the phyllites) and pinch out in deeper basins formed over less resistant phyllites and schists. Gold deposits found in the basal conglomerate were certainly controlled by paleotopography, and the influence of paleotopography on sedimentation would have probably continued until basins were filled by sedimentation.

Finally, at least two and possibly three periods of silicification are common to all Tertiary ore deposits. Although the role of each period has not been documented, silicification appears to have at least accompanied mineralization and early periods of silicification may have influenced Au and Ag deposition.

3.) The proximity of favorable host rocks, fracturing, and Tertiary igneous activity to a metal source may have controlled the distribution of the Tertiary ores. Plate I shows the distribution of mining districts surrounding the "Lead-Deadwood Window". Although other sources cannot be precluded, the distribution of the mining districts suggests that the Homestake formation is the most likely source of Au and Ag in Tertiary ores. Rye and Rye (1974) did a stable isotope study in the northern Black Hills; mostly to determine the character of the Homestake formation, but the possible influence of the Tertiary intrusives was also considered. Their work indicates that the hydrothermal fluids responsible for depositing sulphides in the Tertiary ores obtained sulfur from the primary sulphides in Precambrian rocks. They also showed that meteoric water played an important, but probably not a singular role, in Tertiary mineralization. Norton (1983), on the basis of similarities in chemistry, argues that the constituents for the Tertiary ores and gangues were derived from the chemically similar constituents found in the Homestake formation.

Summary

The Homestake Mine produces gold from the high folded Precambrian Homestake formation. Gold is considered to be syngenetic with the deposition of a carbonate iron formation (Homestake formation) and was subsequently concentrated in fold noses during folding and metamorphism. Precambrian

gold deposits in the Black Hills are generally found in rocks that have been metamorphosed to at least garnet grade; at the garnet isograd, the Homestake formation becomes a cummingtonite-quartz schist.

Tertiary Au and Ag deposits largely occur in the Cambrian Deadwood and Mississippean Pahasapa formations, but significant production has also come from brecciated Tertiary intrusive rocks. In Paleozoic sediments, the Au and Ag mineralization occurs as replacement deposits in carbonate units associated with two (possibly three) periods of silicification and high angle fractures that cut the carbonates. Tertiary ore deposits are intimately related to Tertiary igneous activity and Au and Ag were probably derived from the Precambrian metasediments. High angle fracturing that seems to control mineralization is probably related to Laramide doming as well as Tertiary intrusive activity. Additional Au and Ag deposits could possibly exist in both Paloezoic sediments and Tertiary igneous rocks north and east of the "Lead-Deadwood Window" where the Precambrian rocks disappear under Paleozoic sediments.

Bibliography

Allen, A.W., ed., 1931, The Homestake Enterprise: Eng. Min. Jour., Vol. 132, No. 7, pp. 287-338.

Allsman, P.T., 1940, Reconnaissance of gold mining districts in the Black Hills, South Dakota: U.S. Bur. Mines Bull. 427, 146p.

Bayley, R.W., 1970, Structure and mineralization of Precambrian rocks in the Galena-Roubaix District, Black Hills, South Dakota: U.S. Geol. Sur. Bull. 1312-E, 15p.

Chinn, W., 1969, Structural and mineralogical studies at the Homestake Mine, Lead, South Dakota: unpubl. Ph.D. dissertation, University of California, Berkley, 197p.

Darton, N.H. and Paige, S., 1925, Central Black Hills folio (219): U.S. Geol. Sur. Geologic Atlas.

Devereaux, W.B., 1882, The occurrence of gold in the Potsdam formation, Black Hills, South Dakota: Am. Inst. Min. Eng., Trans., v. 17, p. 465-475.

Gustafson, J.K., 1933, Metamorphism and hydrothermal alteration of the Homestake gold-bearing formation: Econ. Geol., V. 28, p. 123-162.

Irving, J.D., 1904 Economic resources of the northern Black Hills, with contributions by S.F. Emmons and T.A. Jaggar, Jr.: U.S. Geol. Sur. Prof. Paper 26, 222 p.

Kulik, J.W., 1965, Stratigraphy of the Deadwood formation, South Dakota and Wyoming: unpubl. M.S. thesis, South Dakota School of Mines and Technology, 263p.

Lisenbee, A.L., 1981, Studies of the Tertiary intrusions of the northern Black Hills uplift, South Dakota and Wyoming: A historical review, in Rich, F.J., ed., Geology of the Black Hills, South Dakota and Wyoming: Geological Society of America, Rocky Mountain section Field Trip Guidebook, 221p.

Noble, J.A., 1950, Ore mineralization in the Homestake Gold Mine, Lead, South Dakota: Geol. Soc. Am. Bull., Vol. 61, pp.221-251.

Noble, J.W. and Harder, J.O., 1948, Stratigraphy and metamorphism in a part of the northern Black Hills and the Homestake Mine, Lead, South Dakota: Geol. Soc. Am. Bull., V. 59, pp. 941-976.

Noble, J.W., Harder, J.O., and Slaughter, A.L., 1949, Structure of a part of the northern Black Hills and the Homestake Mine, Lead, South Dakota: Geol. Soc. Am. Bull., V. 60, pp. 321-352.

Norton, J.J., 1974, Gold in the Black Hills, South Dakota, and how new deposits might be found: U.S. Geol. Sur. Cir. 699, 22p.

Norton, J.J., 1983, Bald Mountain gold mining region, northern Black Hills, South Dakota: U.S. Geol. Sur. Open-file Rep. 83-791, 18p.

Rye, D.M. and Rye, R.O., 1974, Homestake gold mine, South Dakota -- I. Stable isotope studies: Econ. Geol. V. 69, pp. 293-317.

Rye, D.M., Doe, B.R., and Delevaux, M.H., 1974, Homestake gold mine, South Dakota -- II. Lead Isotopes, mineralization ages and source of lead in ores of the northern Black Hills: Econ. Geol., V. 69, pp. 814-822.

Sawkins, F.J., and Rye, D.M., 1974, Relationship of Homestake-type gold deposits to iron-rich Precambrian sedimentary rocks: Inst. Min. and Metall., pp. B56-B58.

Shapiro, L.H. and Gries, J.P., 1970, Ore deposits in rocks of Paleozoic and Tertiary age of the northern Black Hills, South Dakota: U.S. Geol. Sur. Open-File Rep. 70-300, 235p.

Slaughter, A.L., 1968, Homestake mine: in Wyoming Geol. Assoc. Guidebook, Twentieth Annual Field Conference-1968, pp. 157-171.

Smith, F.C., 1897, The Potsdam gold ores of the Black Hills of South Dakota: Am. Inst. Min. Eng. Trans., V. 27, pp. 404-428.

SECTION 36 STRATIGRAPHY

Th tp sill

"BASAL" quartzite (30-50')

Sill - quartz monzonite (100')

Quartzite 40' discontinuous

Sill - 100'-120' quartz monzonite

Shale, dolomite 30' or so

Sill quartz monzonite 80' + 40' of Cd shale + Sill 80'

Top shale 30-40' of Cd + Ow ss & green sh (20')

382 - 1080-1085 - @ 9:30

~10'/hr.

DATE: MARCH 3, 1988

TO: R.L. OUTZEN

FROM: J.N. BARRON

SUBJECT: PROPOSED DEVELOPMENT AND EXPLORATION TARGETS

Numerous opportunities for reserve expansion beyond the planned oxide mining phase exist at our Gilt Edge properties. Earlier this year we were able to show the potential for deep mineralization based on a few past drill holes. Based on this information and the most comprehensive geologic compilation ever completed on the project, we have identified several targets which appear likely to add reserves to those currently identified. These target areas are shown on the accompanying maps and are based on current geologic information. The "confidence level" which we can assign to these various targets, as to the likelihood of adding new reserves, of course, diminishes outward from the area of proven/probable reserves because of comparative lack of information in those areas. However, the geologic relationships of structure, favorable rock types, alteration, and the presence of gold in drill and/or surface samples make these areas prime targets for further exploration. Indeed, some of the best "hunting ground" lies immediately adjacent, both at depth and laterally, to the proposed "28 MMT Sulfide Pit" developed by Wright Engineers, Ltd.

Three maps accompany this report. Map 1 is at a scale of 1"=100' and shows current drill hole locations, outlines of the quartz trachyte porphyry stocks and trachyte porphyry in color and uncolored Deadwood Fm. and pC rocks (lumped). Based on the presently developed geologic model, favorable structural zones, presence of strong alteration and gold values from surface samples, close-in or proximal targets have been identified. These targets are briefly described in Table 1. These target areas are 1) Deep Sulfide Target, 2) North Strawberry/Anchor Hill, 3) Langley, 4) Langley Extension, and 5) Hoodoo. This map also shows the proposed approximate 200' x 200' drilling in the North Strawberry/Anchor Hill area. Much of the drill-indicated and inferred ore calculated by Dick Nielsen lies beneath the leach pad which cannot be drilled at this time. However, the geologic potential west of the leach pad and marginal to the Anchor Hill stock in the Deadwood Fm. and contact zone of the stock are targets for this drilling program.

Map 2 is at a 1"=500' scale and shows areas of alteration and surface gold anomalies at levels $\geq$ .1 ppm (blue) and $\geq$ 1.0 ppm or .030 OPT Au (red). This map is intended to depict the widespread nature of favorable alteration and highly anomalous gold mineralization in undrilled areas.

Map 3 outlines the more grass roots or distal targets based on the information shown on Map 2. Proximal targets are those generally defined by some amount of favorable drill intercepts in combination with favorable rock types, structure, alteration and surface gold anomalies >.03 OPT Au (shown in red). Exploration targets shown in blue are undrilled but do show favorable rock types, structural trends, strong alteration and surface gold values >.03 OPT Au (although generally more scattered). Table 2 describes these undrilled, but on all other accounts, favorable exploration areas.

In summary, I'm very excited about these exploration targets. Our present reserve is based primarily on one, relatively small, densely drilled area displaying many of the same geologic and mineralization characteristics seen in the surrounding undrilled areas. I believe there is a high probability of adding significantly to our present reserves with continued work in these areas.

Jim

James N. Barron

JNB/dvl

cc: James A. Anderson,
Ventures Trident

Doug Stewart,
Brohm Mining Corporation

Attachments

TABLE 1
PROPOSED EXPLORATION TARGETS - GILT EDGE PROJECT

AREA/TARGET	PRIORITY	GOLD MINERALISATION TARGET	GEOLOGIC BASIS	PROPOSED EVALUATION
DEEP SULFIDE TARGET	1	TRACHYTE PORPHYRY PRIMARY HOST ROCK with faulted, brecciated quartz trachyte porphyry, Deadwood Fm. and pC rocks as secondary host rocks.	Highest grade gold ore and most intense alteration is developed in highly brecciated trachyte porphyry marginal to quartz trachyte stocks and plugs and in wide fracture zones (up to 200'+) trending NE and NW. Ore zones in these highly fractured rocks are open at depth. Very good potential for development of 60 MMT+ of sulfide ore at .04 - .05 OPT Au. One of the 1988 drill holes has extended known ore grade gold mineralization at depth more than 800' to the NE along the Rattlesnake Fracture zone.	Deep exploration/development drilling program proposed and initiated. Thirteen rotary holes drilled to date with encouraging results. Drilling program currently on hold awaiting project financing. Phase I of the program was $1.6 MM in order to obtain 200 x 200 feet centers. A second phase of infill drilling based on Phase I results may be necessary to formulate proven/probable reserves.
NORTH STRAWBERRY		CAMBRIAN DEADWOOD FM. PRIMARY HOST ROCK. Strataform and fault-controlled gold mineralization.	Ore-grade gold mineralization developed in basal quartzite and calcareous shale units lateral to north-trending faults. Mineralization is strataform and fault-controlled and generally within 400' of surface. Ore is mostly sulfide. Present drill-indicated and inferred reserves calculated of 3.18 MMT @ .044 OPT with geologic potential of an additional 9.8 MMT at an estimated grade of .04 OPT Au. Gold mineralization up to 125' of .201 OPT Au in highly faulted areas.	Most of drill indicated reserves are present below leach pad. Therefore, infill drilling of this area is not planned at this time. Drilling of geologic potential to west of leach pad is combined with proposed Anchor Hill/North Strawberry infill/exploration drilling program of 40 drill holes (see below).

TABLE 1
PROPOSED EXPLORATION TARGETS - GILT EDGE PROJECT

AREA/TARGET	PRIORITY	GOLD MINERALIZATION TARGET	GEOLOGIC BASIS	PROPOSED EVALUATION
ANCHOR HILL/ NORTH STRAWBERRY	2	CAMBRIAN DEADWOOD FM. PRIMARY HOST ROCK, with faulted quartz trachyte porphyry of Anchor Hill stock as secondary host. Deadwood Fm. breccia marginal to Anchor Hill stock, strataform and fault-controlled gold mineralization.	Limited drilling south of Anchor Hill stock indicates Deadwood Fm. - hosted gold mineralization, generally less than 250' in depth. Up to 55' thick drill intercepts averaging .020-.051 OPT Au present. Strong NE trending gold geochem anomaly with indications of intersection with NW mineralized trend extending from Hoodoo Mine through Union Hill stock to plant site at south end of Anchor Hill. As in the Dakota Maid area, brecciated Deadwood Fm. marginal to the Anchor Hill stock and fault-controlled plus strataform replacement mineralization west of the leach pad in areas of drill indicated reserves are primary targets for proposed drilling program. The Anchor Hill quartz trachyte porphyry contains oxidized and mixed oxide plus sulfide gold mineralization in all three holes drilled in it thus far. The two vertical holes contain 110' and 185' of continuous gold mineralization averaging .046 and .029 OPT Au respectively above depths of 475' in the contact zone.	40 hole rotary drilling program on approximate 200 x 200 foot spacing proposed in order to test the continuity of geologic potential identified west of drill-indicated and inferred reserves under leach pad in Deadwood Fm. The proposed drilling is also formulated to test potential for brecciated, Deadwood-hosted gold mineralization marginal to the Anchor Hill stock as well as quartz trachyte-hosted gold mineralization at the margin and at sites of gold anomalies along inferred structures. Proposed Program: Hole locations shown on 1"=100' scale map. 16,000 feet rotary drilling Total Cost = approximately $320,000 Drilling start-up, based on rig availability, could begin immediately in eastern portion of target area. IP/RES.

TABLE 1
PROPOSED EXPLORATION TARGETS - GILT EDGE PROJECT

AREA/TARGET	PRIORITY	GOLD MINERALIZATION TARGET	GEOLOGIC BASIS	PROPOSED EVALUATION
LANGLEY TARGET	3	TRACHYTE PROPHYRY, DEADWOOD FM. AND pC ROCKS, at the brecciated and faulted margin of the Langley quartz trachyte prophyry stock.	Economic oxide and sulfide gold mineralization is now being developed marginal to the Union Hill quartz trachyte prophyry stock to the north. Grade x thickness relationships display a remarkable aureole around the Union Hill stock margin which is also the source for previously mined high-grade gold ores. Past limited drilling is restricted to the northern margin of the Langley stock. However, this drilling indicates not only shallow oxide, ore-grade gold mineralization, but some of the richest and most continuous gold intercepts drilled on the Gilt Edge property to date, e.g., deep core holes containing 400' to 580' averaging +.08 OPT Au as deep as 1400'. Surface sampling along the eastern, southern and western margins of the Langley stock shows a gold halo similar to the grade x thickness halo surrounding the Union Hill stock, with pods of +.030 OPT Au surrounding the Langley stock. One surface sample was as high as .222 OPT Au. This is a previously undrilled area which begs for exploration drilling in order to make additions to both near-surface oxidized ore and sulfide ore at depth. Favorable areas of mapped brecciation are present at the surface as well as northeast trending fault zones from the Oro Fino shaft on the south to the Hoodoo shaft on the north, along which fault breccia has been mapped.	A drilling program has not been laid out for this area as yet. However, an initial 10-12 drill hole program consisting of both angle and vertical rotary drill holes located in areas of highest surface sample results and mapped zones of brecciation could be formulated and initiated to coincide with the proposed North Strawberry/Anchor Hill drilling program. If results justified further exploration, a second phase of exploration would be formulated. Proposed Program: 6,000 feet of rotary drilling Est. Total Cost = $120,000.00 IP/RES.

TABLE 1
PROPOSED EXPLORATION TARGETS - GILT EDGE PROJECT

AREA/TARGET	PRIORITY	GOLD MINERALIZATION TARGET	GEOLOGIC BASIS	PROPOSED EVALUATION
LANGLEY EXTENSION	4	CAMBRIAN DEADWOOD FM., TRACHYTE PORPHYRY and pC ROCKS. Highly faulted and fractured rocks in which strataform (Deadwood) and fault-controlled gold mineralization in all three rock types may possibly add to present reserves and contribute to maintaining a lower stripping ratio for the Deep Sulfide Target in the main mine area.	A major fault zone trending north from the western margin of the Langley stock to the plant site area is present. Trachyte porphyry is intruded along and within the fault zone and spreads out as a sill-like mass west of Strawberry Creek. Faulted Deadwood and pC rocks are also present and form the basis for possible strataform and fault-controlled mineralization. Several +.030 OPT Au surface samples outline this fault zone. However, no drilling has occurred along the trace of this favorable fault zone. Four surface samples exceed .10 OPT Au, one of these is 1.9 OPT Au.	Conduct in-fill surface sampling and more detailed geologic mapping of this zone west of the Dakota Maid oxide pit in order to better identify possible follow-up drill sites. Possible ID/Resistivity
HOODOO TARGET	5	TRACHYTE PORPHYRY, DEADWOOD FM., pC ROCKS. Fault-controlled mineralization in trachyte porphyry, Deadwood Fm, and along the trachyte-pC contact zone. Ore additions here, like the Langley Extension, would contribute to lowering the stripping ratio for the Deep Sulfide Target in the main mine area.	Widely-spaced (200' x 200') condemnation drilling conducted during 1987 in this area showed the presence of low to high-grade gold intercepts along a NW trending mineralized fault zone extending from this area toward Anchor Hill, essentially open at both ends. Mineralized drill intercepts range in depth from the surface to 600', in thickness from 5 to 215', and in grade ranging above a cutoff of .02 OPT to 75' averaging .144 OPT.	Conduct in-fill surface sampling + more detailed geologic mapping in order to identify more refined drilling targets. This work is aimed at defining up-dip extensions of fault-controlled gold mineralization in order to define ore contributions in this area now considered as waste in the Deep Sulfide Target area.
FOLLOWING TARGETS ARE UNDRILLED IN WHICH ONLY CURSORY SURFACE SAMPLING/ MAPPING HAS BEEN CONDUCTED CONDUCTED				

TABLE 2
PROPOSED EXPLORATION TARGETS - GILT EDGE PROJECT

AREA/TARGET	PRIORITY	GOLD MINERALISATION TARGET	GEOLOGIC BASIS	PROPOSED EVALUATION
NORTH STRAWBERRY EXTENSION		DEADWOOD Fm. Oxide & sulfide gold mineralization.	Northward extension of North and NE structures responsible for mineralization identified in the North Strawberry and Anchor Hill targets coincide in this area. Cursory surface sampling in this area identifies a zone of +.030 OPT Au. Strong surface alteration has also been identified by Dick Nielsen in mapping conducted last fall. Oxide as well as sulfide gold mineralization is possible in this area, possibly as strataform bodies within the Deadwood Fm.	Surface sampling and geologic mapping to identify drilling targets.
RATTLESNAKE EXTENSION, RUBY RIDGE AND BUTCHER TRENDS		TRACHYTE PORPHYRY AND DEADWOOD Fm. Oxide & sulfide gold mineralization	The northern portion of the NE trending Rattlesnake fracture zone is only poorly identified. Faults alteration patterns and surface gold anomalies take on a stronger NW trend in these areas. Cursory sampling shows some areas of +.030 OPT Au anomalies which can now be explored because of recent land acquisitions in those areas.	Surface sampling and geologic mapping to further identify drilling targets.
GOLDEN CREST		DEADWOOD Fm. Strataform and fault-controlled oxide and sulfide gold mineralization.	Area of unrecorded previous mining northwest of main mine area. This area is currently poorly understood. No sampling or drilling has occurred here in recent history. Although exposures are rare, the Deadwood Fm. is the postulated host for past production. Projection of NW trending structures in main Gilt Edge area coincide with area of Golden Crest. Thermal alteration mapped in this area where Deadwood is exposed as small "windows" through horneblende trachyte sill.	Surface sampling & more detailed mapping needed to identify drill targets. Amount of cover in area may lend itself to IP/resistivity survey techniques to help identify target.

TABLE 2
PROPOSED EXPLORATION TARGETS - GILT EDGE PROJECT

AREA/TARGET	PRIORITY	GOLD MINERALIZATION TARGET	GEOLOGIC BASIS	PROPOSED EVALUATION
HOODOO RIDGE		DEADWOOD FM. and pC ROCKS. Brecciated rocks marginal to the Hoodoo quartz trachyte porphyry intrusive.	Totally unexplored area east of main Gilt Edge area. Newly acquired in 1988, our land position now affords the opportunity to explore Deadwood Fm. and pC rocks intruded by this northwest trending feeder. Strong alteration was mapped by Neilsen in both the quartz trachyte and the Deadwood Fm. and pC rocks marginal to the intrusive.	Surface sampling and follow up geologic mapping necessary to define drilling targets.
GOLDEN CREST EXTENSION		DEADWOOD FM. Strataform and fault controlled gold mineralization.	A large area of thermal and hydrothermal alteration was mapped by Tom Patton late last year extending northwest from the Golden Crest Mine area. The most intense alteration was seen in Deadwood Fm. rocks exposed in small 'windows' through sills of hornblende trachyte. Because of these relatively small areas of exposed Deadwood, the few +.030 OPT Au surface samples are restricted in this area. However, this large area of widespread alteration and anomalous gold geochem deserves much more attention in order to define possible structural controls on mineralization.	Surface sampling and follow up geologic mapping necessary to define drilling targets.

Continuation of Phase I - Compiled 3/28/88 - 200' centers

Proposed Drill Holes - 1988 Sulfide Z

3/30/88

Section	Easting	Proposed Depth	Az/Bearing		Priority	Target
44,400 N	125,705	300'	—	—	2	fault, Edg, pE
44,500 ★	126 960	600				
44,400N	127,070	1325' (1000' min)	—	—	1	Ttp, fault, Tbxa
"	127,270	800	—	—	2	Ttp, fault
"	127,470	700' 3125	—	—	2	Ttp, pE contact zone
44,600N	125,580	600	—	—	2	Edh, Edg, ~~pE~~ fault
★	126, 850	900				
	127, 000	1400 (1100 min)	—	—	1	Ttp, Tbxa.
	127,200	800	—	—	1	Ttp,
	127,400	600 3400	—	—	2	Ttp, fault zone, pE contact
44800N	126,000	500	—	—	2	pE, fault
	127,000	1400 (1200 min)	—	—	1	Ttp, fault (deep)
	127,300	950	—	—	1	Ttp
	127,500	650 2500	—	—	2	Ttp, fault, pE contact
45,000 N	125,990	400	—	—	2	pE, Creek fault
	126,900	1350	—	—	1	Ttp
	127,100	1250	—	—	1	Ttp
	127,300	1050	—	—	2	Ttp, pE Contact
	127,500	850 4700 1025	—	—	2	Ttp, pE Contact
45,200N	125,980	650	—	—	2	pE, DMFZ, Creek fault
	126,890	1500	—	—	1	Tgtp, Tbxa, Ttp, CFZ,
	127,080	1900	—	—	1	Tgtp, Tbxa, Ttp, CFZ
	127,230	1000	—	—	1	Ttp, CFZ.
	127,950	900	—	—	2	Ttp, pE contact
	127,800	650	—	—	2	Ttp, fault,

otion	Easting	Proposed Depth	Az/Inclin. Bearing	Priority	Target
45,400 N	125,805	300	— —	2	€, pE, Ttp, Creek fault
	126,000	A) 1000'	— —	1	€, pE, Ttp, DMFZ, Creek fault
		B) 1500'	E-W, -75°		Ttp, DMFZ, Ttp/Tgtp margin
	126,200	A) 1200'	— —	1	Ttp, DMFZ, pE contact
		B) 1200'	E-W, -75°		Ttp, Tgtp/Ttp margin, Tgtp min.
	126,810	600'	— —	1	Tgtp FZ
	127,330	1250	— —	1	Ttp, RFZ, pE contact
	127,640	950	— —	2	Ttp, NW fault tc, pE contact
45,600 N	125,775	450	— —	2	Ttp, pE contact, Creek fault
	126,000	1200'	— —	1	Ttp, Creek fault
	126,170	1400'	— —	1	Ttp,
	126,370	1500'	— —	1	Tbxa, Tgtp margin, Tgtp min.
	126,610	1200'	— —	2	Tgtp min.
	126,910	700'	— —	2	Tgtp FZ
	127,450	1550'	— —	1	Ttp, pE Contact, NW fault zone
	127,650	750'	— —	2	Ttp, pE Contact
45,800 N	125,875	1050	— —	2	€, pE, Ttp, Creek fault
	126,235	A) 700	— —	1	€, pE, possible fault zone
	"	B 1250	— —	1	" " " " "
	127,500	1200	— —	1	Ttp, pE contact, RFZ
	127,790	700	— —	2	Ttp,

SECTION	EASTING	PROPOSED DEPTH	AZ/BEARING	PRIORITY	TARGET
45,950N ★	126,295	950	— —	1	€, pE, Tbxa, possible NE fault
46000 N	125,750	850	— —	2	Ttp, €, pE, Creek fault
	126,095	800	— —	2	€, pE
	~~126,295~~	~~950~~	— —	1	~~€, pE, Tbxa, possible NE fault~~
	127,450	1050	— —	1	Ttp,
	127,650	750	— —	2	Ttp, pE contact
	127,900	650 600	— —	2	€, pE, RFZ
46,100 ★	126,400	1100	— —	1	€, pE,
46,200	126,065	250	— —	2	€
	126,820	550	— —	2	€, pE
	127,175	1050	— —	1	Ttp, UHFZ
	127,435	700 2550	— —	2	Ttp
TOTAL	54	49,475	(916'/hole)	@$25/ft	1.24 } w/o CONTINGENCY
#1 only	26	30,175	(1160/hole)	@$25/ft =	.755 }

PROPOSED 1988 DRILL TARGETS - GILT EDGE EXTENSION PROJECT

		N	E	ELEVATION	DEPTH	BEARING	INCL.	COMMENTS
	1	44600'	27900	5300	600'	—	-90°	Test pE / Ttp contact
HOO DOO AREA	2	44700'	27700	5360	400'	—	-90°	Same
	3	44600'	28100	5260	600	—	-90°	Same
	4	44800'	28000	5310	800'	—	-90°	Same
	5	44850'	27700	5395	600'	—	-90°	Same
	6	49500'	27700	5350	800'	—	-90°	Same
	7	44400'	27600	5405	600'	—	-90°	Same, Geochem
					4400'			
EAST OF LANGLEY STOCK	8	44250	27050	5550	500'	N90 E	-45°	Test Langley (Ttatp) / Ttp, Ttp / pE contacts, west dipping fault
	9	43950	26950	5560	500'	N 90 E	-45°	Same as #8
	10	43800	27050	5450	800	—	-90°	Test Ttatp / Ttp contact
	11	43700	26750	5435	600'	—	-90°	Test Ttatp / Ttp contact, pE contact, west dipping fault
	12	43800	26800	5475	1000'	N 90° E	-90°	same as #8 + 9
					3400			
WEST OF LANGLEY	13	43650	26150	5235	600'	—	-90	Test geochem anomaly
	14	43875	25150	5295	400'	—	-90°	Test geochem anomaly, south dipping flt.
	15	44050	25450	5275	600'	—	-90°	Test Ttatp / pE contact, Strawberry Creek Flt
	16	44075	25250	5325	600'	—	-90°	Test geochem anomaly
	17	44200	25475	5280	570'	N90 W	-45°	Test Ttatp / Tiöxa / Ed contacts, Strawberry Creek Flt.
	18	44100	25050	5345	600'	—	-90°	Test geochem anomaly
					3370			
WEST OF DAKOTA MAID	19	44600'	26000	5312	600'	—	-90°	Test pE / Ttatp contact near King Cabin
	20	44750'	25900	5325	400'	—	-90°	Academy admin, bldg sight
	21	45000'	25200	5400	600'	—	-90°	Geochem anomaly
	22	45300	25000	5450	600'	—	-90°	Geochem anomaly, Ed / Ttp contact
	23	45500	25100	5455	600	—	-90	Geochem anomaly in Ttp.
					2800'			
				TOTAL	13,970			